REMARKS

This Amendment is filed in response to the Office Action dated March 1, 2005, which has a shortened statutory period set to expire June 1, 2005.

Applicants Address The 112 Rejections

With respect to Claims 1-6 and 17-20, the Office Action states, "The simulation that produces data for parameters that are unknown or unspecified at the time of simulation is not enabled by the disclosure. Particularly lacking are the process by which the inventive simulation operates, the form taken by the simulation results, and how the database interface relates specified simulation parameters to the simulation data."

Applicants recited database captures certain information about a simulation, thereby allowing a new tolerance to leverage the results of that simulation (in contrast to the prior art, e.g. paragraph [0005]). Specifically, a prior art simulation would output a graphical output including the original layout with contours showing the simulated wafer image. Paragraph [0004]. Areas of the layout exceeding a user-defined tolerance (which is requested before the simulation) are typically marked by graphical symbols. Paragraph [0004]. Applicants have described the state of the art in the Specification, paragraphs [0002]-[0005].

In contrast, as taught by Applicants in the Specification (emphasis added) with respect to the recited database,

> [0029] If the deviation of a control point is greater than its tolerance (as determined by simulation module 102), then the deviation of this control point can be written to the database. Of importance, **the actual magnitude of the deviation as well its the direction** (wherein "+" indicates a deviation outside the feature as defined by the original layout and a "-" indicates a deviation inside the feature) **can be written to the database**. Note

> that **in current simulation tools the presence and location of the deviation can be accessed. However, the user is unable to access more in-depth information to facilitate more useful simulation results.**

Therefore, the simulation itself is not the object of Applicants' invention. Rather, the invention relates to a novel database that can capture information regarding that simulation to minimize the need to repeat the simulation process. For example, assume a user has designated 10 nm as the tolerance. In this case, a prior art simulation output could graphically show each location where a deviation greater than the tolerance occurs. However, if the user changes the tolerance to 11 nm, then another simulation must be performed to provide the new data. In contrast, the actual deviation (e.g. +12 nm) of a control point can be captured in Applicants' recited database. In this case, if the user changes the tolerance from 10 nm, the database can easily be searched to find any deviations greater than 10 nm (e.g. 11 nm, 12 nm, 13 nm, etc.).

As noted by Applicants,

> [0030] Because users tend to set tight tolerances, the database would typically store information regarding a significant subset of the control points in the layout. In this the manner, the time-consuming step of simulation need only be performed once to provide the information needed to generate the multitude of reports that could later be requested by the user. In accordance with one feature of the invention, the detailed control point information stored in the database allows the simulation tool to generate flexible and dynamic reporting of the simulation results.

The information in the database can be organized into various tables to facilitate reporting. Specification, paragraph [0034]. Exemplary tables are described in reference to Figures 3, 4, and 5. As taught by Applicant,

[0035] Figure 3 illustrates an exemplary main table 300 in which each row corresponds to a control point whose deviation is greater than the tolerance. Thus, in Figure 3, control points 301, 302, 303, and 304 have deviations greater than the set tolerances for those points. The columns in main table 300 can include, for example, cell name, type, rule identification, location (e.g. x and y coordinates), deviation (e.g. in nanometers), and the angle along which the deviation is defined.

[0036] The statistics table includes information that can be used to calculate and/or provide the mean (average) deviation and the standard deviation for any selected group of control points. Figure 4 illustrates an exemplary statistics ("stat") table 400 in which the selected group of control points could be in a cell, of a specific type (e.g. line end control points), and designated by a rule identification (e.g. edge control points with features having a width between 100 nm and 199 nm). The columns in stat table 400 could include, for example, a mean (i.e. an average deviation for the cell, type, and rule identification), a sum of the squares of deviations (an intermediate step in determining the variance), a variance (i.e. an average of the squares of the deviations of the deviations about the mean), and a standard deviation (i.e. the positive square root of the variance, thereby providing a measure of variability in nanometers).

[0037] Figure 5 illustrates an exemplary cell table 500, which provides information regarding specific cells in the layout. In cell table 500, information regarding the number of control points and the simulation time for those control points is provided for cells 501, 502, and 503. Other information could include, for example, the number of reported errors for each cell.

The Office Action requests a citation to the part of the Specification that describes the limitations of Claims 6 and 16. As taught by Applicants in the Specification,

[0025] Each type of control point can be further characterized by assigning it a rule identification. For example, edge type control points can be divided

into groups by a feature width w (measured perpendicular from an edge, typically at the control point, to the next edge of the feature). In one embodiment, the edge type control points can be divided into four groups as follows:

```
set    EdgeRuleTable {
    {"100<=w<200" 1}
    {"200<=w<300" 2}
    {"300<=w<400" 3}
    {"400<=w<max" 4}
    }
```

Thus, edge type control points having an associated feature width between 100 nm and 199 nm can be assigned a rule identification designation "1"; edge type control points having an associated feature width between 200 nm and 299 nm can be assigned a rule identification designation "2"; edge type control points having an associated feature width between 300 nm and 399 nm can be assigned a rule identification designation "3"; and edge type control points having an associated feature width greater than 400 nm can be assigned a rule identification designation "4". The rule identifications can be programmed by a user or set automatically by the dissection module.

Therefore, as indicated in paragraph [0025], this rule identification can be a programmable feature that can be changed by the user or set by the dissection module. Because these rules are layout dependent, not simulation dependent, these rules can clearly be changed without performing an additional simulation. Based on these remarks, Applicants submit that the limitations of Claims 6 and 16 are enabled.

Based on the above remarks, Applicants respectfully submit that Claims 1-6 and 17-20 comply with the enablement requirement. Therefore, Applicants request reconsideration and withdrawal of the rejection of Claims 1-6 and 17-20 under 35 U.S.C. 112, first paragraph.

Applicants have amended Claims 7-16 to clarity that the layout refers to an integrated circuit layout. Based on these amendments, Applicants submit that Claims 7-16 are enabled.

Applicants have amended Claims 1, 4, 5, 7, 14, 15, 17, and 20. Based on these amendments, Applicants submit that Claims 4, 5, 7, 14, 15, and 20 particularly point out and distinctly claim the subject matter of the invention. Specifically, Claims 1, 4, 5, 17, and 20 now recite a "subset of information" from the database. Support for this limitation is provided, for example, in paragraphs [0039] and [0041]. Moreover, Claims 4, 14, and 20 now recite "wherein the temporary table is separate from the database." Moreover, Claims 5 and 15 now recite "Graphics Data Syntax (GDS mode)". Based on these amendments, Applicants request reconsideration and withdrawal of the rejection of Claims 4, 5, 7, 14, 15, and 20 under 35 U.S.C. 112, second paragraph.

Claims 1-20 Are Patentable Over Chang In View Of Cox

In designing an integrated circuit (IC), engineers typically rely upon computer simulation tools to help create a circuit schematic design consisting of individual devices coupled together to perform a certain function. To actually fabricate this circuit in a semiconductor substrate the circuit must be translated into a physical representation, or layout, which itself can then be transferred onto a template (i.e., mask), and then to the silicon surface. Again, computer aided design (CAD) tools assist layout designers in the task of translating the discrete circuit elements into shapes, which will embody the devices themselves in the completed IC. These shapes make up the individual components of the circuit, such as gate electrodes, field oxidation regions, diffusion regions,

metal interconnections, and so on. As taught by Applicants in the Specification:

> [0002] In sub-wavelength designs, traditional design rule checking (DRC) tools cannot be relied upon as a final check for silicon manufacturability. Specifically, because features can be distorted during the sub-wavelength manufacturing process due to both local and global proximity effects, DRC tools cannot provide the coverage and assurance needed for silicon sign-off.
>
> [0003] To resolve this problem, certain simulation tools have been provided that can verify the layout of a sub-wavelength integrated circuit compared to the printed wafer. Numerical Technologies, Inc. licenses such a tool, the SiVL® software package. This simulation tool can read in a user's layout and then simulate lithographic processes and conditions. The resulting simulated wafer image can be compared to the user's layout.
>
> [0004] Prior to this comparison step, the user is generally prompted to designate a tolerance, i.e. a maximum acceptable deviation, from the user's original layout. In one embodiment, the simulation tool can generate a graphical output including the original layout with contours showing the simulated wafer image. An area of the layout exceeding the tolerance can be marked with a graphical symbol, such as a "+" or "■". See, for example, U.S. Patent Application Serial No. 09/960,669, filed on September 21, 2001 by Numerical Technologies, Inc. Understanding where tolerance violations occur can indicate problems with the design or perhaps errors in providing rule parameters. However, setting a zero-tolerance can result in a large number of tolerance violations throughout the layout. Thus, setting the tolerance too tight generates too much information for a useful user review. Moreover, the appropriate tolerance can vary significantly from one design to another design. Therefore, determining an appropriate tolerance that can provide useful simulation results is frequently a trial and error process.
>
> [0005] Unfortunately, a new tolerance cannot leverage the results of a previous simulation. Specifically, setting a new tolerance requires repeating the

simulation, thereby wasting considerable resources. For example, a medium-sized integrated circuit layout may take between 12 and 24 hours to simulate. Thus, the simulation tool is inefficiently used to re-run simulations on the same design rather than running new designs. Moreover, after this long process time, the user analysis done for proposing that specific tolerance may not be retained, thereby requiring further analysis. Thus, user time is also wasted on one design.

[0007] In accordance with one feature of the invention, a user can extract information from a database, which is generated by a one-time simulation of the user's layout. Specifically, designated control point information (e.g. a type, a rule identification, a tolerance, and a target parameter) and detailed deviation information regarding control points on the layout can be stored in the database. The user can tailor various reporting formats to provide the information most pertinent to that user.

[0008] Advantageously, based on the database, a user can easily change information regarding the rule identification, tolerance, and target parameter and still generate valid reports. Because a simulation on a layout need only be done once and accessing a database is significantly faster than simulating a layout, these reports can be expeditiously generated. This flexible and dynamic reporting capability provides the user with a rich source of information regarding the layout, thereby allowing that user to make better-informed decisions on correcting the layout.

Claim 1, as amended, now recites in part:

storing information from the single simulation in a database, wherein the information includes deviation information for at least one control point, the deviation information indicating a deviation of a simulated location from a corresponding location on the integrated circuit layout; and

extracting a subset of information from the database to generate the reports using a first set of checking parameters, wherein extracting is repeatable with a second set of checking parameters without

repeating the steps of providing, performing, and storing.

Applicants traverse a number of characterizations of Chang. Specifically, the Office Action states, "This simulation is particularly concerned with the circuit layout (column 11, line 66 - column 12, line 4) and therefore respects the geometry of the circuit layout." Applicants are confused by the citation of this passage (included below for convenience).

> This data may include parameters such as the numerical aperture of the system (NA), the coherency value of the system (σ), the wavelength of the illumination being used in the system (λ), the defocus of the exposure, lens aberrations, substrate conditions and the critical dimensions of the design among others.

Applicants respectfully submit that this passage teaches nothing regarding the circuit layout.

The Office Action further states, "parameters such as 'critical dimensions of the design' (column 12, lines 3-4) are specific references to what Applicant refers to as 'control points' and are necessarily related to designated information, such as critical dimensions". Applicants respectfully traverse this characterization.

The term "critical dimension" is known by those skilled in the art as a width of a critical feature. An exemplary critical feature could be a gate of a transistor. Therefore, the width of this gate would be considered a critical dimension. In contrast, a control point refers to a point on the edge of a feature, which may or may not be part of a critical feature.

As taught by Applicants in the Specification:

> [0020] Although the complex patterns of an IC layout may seem to be made up of fine lines, even the thinnest of lines are actually two-dimensional elements. As such, these elements can be represented by a series of contiguous edges that are joined to

other edges at distinct corners. The contiguous edges and their associated corners define the features on the layout.

[0021] During an operation performed by dissection module 101, the edges of the features on the layout are divided into segments. In one embodiment, dissection module 101 can generate those segments by using one or more user-defined segment lengths. For example, a user could indicate that all segments should be substantially 120 nm long. In another example, the user could indicate that edges near a corner should be divided into segments 60 nm long. Note that the user could define the segment length(s) by using a graphical user interface (GUI) provided by the dissection module or by using another input method (such as via a technology file or a script). In another embodiment, the segment lengths can be automatically generated by dissection module 101, wherein the module-generated segment lengths can be used instead of, or in combination with, the user-defined segment lengths.

[0022] After dissection, each segment can be designated using an associated control point (sometimes located at the mid-point of the segment). By using a control point, a tool can efficiently operate on its associated segment. Specifically, operations performed on a control point affect its associated segment in a similar manner. For example, if the control point is biased in an optical proximity correction (OPC) operation by a distance X, then its associated segment is also biased by distance X.

Therefore, Applicants submit that the critical dimensions of the design discussed in Chang do not refer to the recited control points.

The Office Action also states, "Chang further teaches that the simulation takes into account a range of parameter values so that the results can be analyzed over a range of possible lithography condition. (column 12, lines 4-10). The process parameters can therefore be adjusted, providing a "second set of checking parameters", and the results are immediately known

without repeating the entire simulation process." Applicants disagree. Changing the lithography conditions would change the printing results. Therefore, the simulation process would have to be repeated with the changed lithography conditions to obtain accurate results.

The Office Action admits that Chang does not explicitly teach storing the results of the simulation in a database or a database interface by which a user may query for the simulation results. The Office Action cites Cox as teaching this simulation database. Applicants also respectfully traverse this characterization.

Cox teaches managing simulation results for an integrated circuit design, not for an integrated circuit layout. For example, as taught by Cox in col. 5, lines 16-24 (emphasis added):

> Bus functional models are used to simulate the bus level operation of an **IC design** at the interface between the IC and the outlying environment. Bus functional modeling is a simulation technique that breaks operations down into functional transactions. A "transaction" is defined herein as a specific sequence of transitions on a collection or grouping of signals (representing a physical interface) over a period of time where signal activity has some higher level operation meaning.

Because Cox teaches managing simulation results for an integrated circuit design, not for an integrated circuit layout, the passages in Cox cited by the Office Action (i.e. col. 2, lines 38-41, col. 2, lines 44-57, and col. 3, lines 48-60) cannot remedy the deficiency of Chang. Because Chang and Cox fail to disclose or suggest the recited steps of storing information from the single simulation in a database and extracting specific information from the database to generate

the reports, Applicants request reconsideration and withdrawal of the rejection of Claim 1.

Claims 2-6 depend from Claim 1 and therefore are patentable for at least the reasons presented for Claim 1. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claims 2-6.

Moreover, Claim 2 recites, "wherein providing the plurality of control points includes designating at least one of a type, a rule identification, a tolerance, and a target parameter for each control point". The cited passage of Chang, i.e. col. 11, line 62 to col. 12, line 4, fails to disclose or suggest these limitations. Therefore, Applicants request further reconsideration and withdrawal of the rejection of Claim 2.

Moreover, Claim 6 recites, "storing new information in the database based on the at least one new rule and the single simulation". The Office Action cites Chang in general for teaching this limitation. Applicants traverse this characterization. Specifically, as noted above, changing the lithography conditions would change the printing results. Therefore, the simulation process would have to be repeated with the changed lithography conditions to obtain accurate results. Therefore, Applicants request further reconsideration and withdrawal of the rejection of Claim 6.

Claim 7, as amended, now recites in part:

> deviation information regarding the plurality of control points, wherein the deviation information indicates deviations of simulated locations from corresponding locations on the integrated circuit layout, the deviation information including a magnitude of each deviation.

Therefore, Claim 7 is patentable for substantially the same reasons presented for Claim 1. Based on those reasons,

Applicants request reconsideration and withdrawal of the rejection of Claim 7.

Claims 8-10 depend from Claim 7 and therefore are patentable for at least the reasons presented for Claim 7. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claims 8-10.

Claim 11, as amended, now recites in part:

> storing simulation information in a database, wherein the simulation information includes deviation information for at least one control point, the deviation information indicating a deviation of a simulated location from a corresponding location on the integrated circuit layout; and
>
> extracting user-identified information from the database to generate the simulation reports.

Therefore, Claim 11 is patentable for substantially the same reasons presented for Claim 1. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claim 11.

Claims 12-16 depend from Claim 11 and therefore are patentable for at least the reasons presented for Claim 11. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claims 12-16.

Moreover, Claim 12 recites, "further includes designating at least one of a type, a rule identification, a tolerance, and a target parameter for each control point". Chang, i.e. col. 11, line 62 to col. 12, line 4, fails to disclose or suggest these limitations. Therefore, Applicants request further reconsideration and withdrawal of the rejection of Claim 12.

Moreover, Claim 16 recites, "further including providing at least one new rule associated with the control points and storing new information in the database based on the at least one new rule and the single simulation". As noted above, changing the lithography conditions would change the printing

results. Therefore, the simulation process would have to be repeated with the changed lithography conditions to obtain accurate results. Therefore, Applicants request further reconsideration and withdrawal of the rejection of Claim 16.

Claim 17, as amended, now recites in part:

> means for storing information from the single simulation in a database, wherein the information includes deviation information for at least one control point, the deviation information indicating a deviation of a simulated location from a corresponding location on the integrated circuit layout; and
>
> means for extracting specific information from the database to generate the reports using a first set of checking parameters, wherein extracting is repeatable with a second set of checking parameters without repeating the steps of providing, performing, and storing.

Therefore, Claim 17 is patentable for substantially the same reasons presented for Claim 1. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claim 17.

Claims 18-20 depend from Claim 17 and therefore are patentable for at least the reasons presented for Claim 17. Based on those reasons, Applicants request reconsideration and withdrawal of the rejection of Claims 18-20.

Moreover, Claim 18 recites, "means for designating at least one of a type, a rule identification, a tolerance, and a target parameter for each control point". Chang, i.e. col. 11, line 62 to col. 12, line 4, fails to disclose or suggest these limitations. Therefore, Applicants request further reconsideration and withdrawal of the rejection of Claim 18.

CONCLUSION

Claims 1-20 are pending in the present Application. Reconsideration and allowance of these claims is respectfully requested.

If there are any questions, please telephone the undersigned at 408-451-5907 to expedite prosecution of this case.

Respectfully submitted,

Customer No.: 29477

Jeanette S. Harms
Attorney for Applicants
Reg. No. 35,537

I hereby certify that this correspondence is being deposited with the United States Postal Service as FIRST CLASS MAIL in an envelope addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on April 25, 2005.

4/25/2005 Rebecca A. Baumann
Date Signature: Rebecca A. Baumann